Implementation and Dissemination of a Military Trauma System: Utilizing Medical Lessons Learned from the Battlefield

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ABSTRACT

Introduction

Derived from the necessity to mitigate injury outcomes across the spectrum of battlefield injury, the Joint Theater Trauma System (JTTS) and Joint Theater Trauma Registry (JTTR) were developed utilizing the

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14. ABSTRACT
Derived from the necessity to mitigate injury outcomes across the spectrum of battlefield injury, the Joint Theater Trauma System (JTTS) and Joint Theater Trauma Registry (JTTR) were developed utilizing the American College of Surgeons Committee on Trauma Optimal Resources model in accordance with the U.S. civilian trauma system approach. This analysis was developed to highlight successes of the JTTS.

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Methods

The JTTR captured demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data on 23,754 casualty injury events from October 2001 through December 2008 for this analysis.

Results

In contrast to civilian trauma systems, the majority of battlefield wounds were penetrating mechanism (66.4%). Of patients admitted to deployed military medical treatment facilities, 23.4% had an injury severity score (ISS) $\geq$16, 21$\pm$4% presented in shock (base deficit >5), 30$\pm$3 % patients required blood and 6.8$\pm$2% required massive transfusion. In response to this complex and severely injured population, the JTTS remedied numerous trauma system issues requiring system leadership and advocacy, education, research, and alterations in clinical care, including the elaboration of 31 evidence-based clinical practice guidelines. Several of the guidelines including those for massive transfusion / damage control resuscitation, burn care, hypothermia prevention and management, wound and amputation management have been associated with demonstrable improvements in combat injury outcomes. The JTTS developed a novel performance improvement process across the global continuum of care, a process responsible for improved battlefield injury survival, notably a mortality rate of 4.1% after admission which is comparable to the U.S. civilian standards. In addition, the JTTS fostered the development of military trauma systems and combat trauma registries in several NATO coalition partners including Canada and the United Kingdom.

Conclusions

The Joint Theater Trauma System has set the standard for trauma care on the contemporary battlefield. The trauma systems approach has been instrumental in fostering medical partnerships with NATO allies and improvements in combat casualty care.

***Key Words**: Trauma, Combat, Trauma System, Performance Improvement, NATO*

BACKGROUND

The development of trauma care has been a synergistic relationship between the military and civilian medical environments for the past two centuries [1-3]. During the Civil War, military physicians realized the utility of prompt attention to the wounded, early debridement and amputation to mitigate the effects of tissue injury and infection, and evacuation of the casualty from the battlefield. World War I saw further advances in the concept of evacuation and the development of echelons of medical care. With World War II, blood transfusion and resuscitative fluids were widely introduced into the combat environment and surgical practice was improved to care for wounded soldiers. From his World War II experiences, Dr. Michael Debakey noted that wars have always promoted advances in trauma care due to the concentrated exposure of military hospitals to large numbers of injured people during a relatively short span of time. Furthermore, this wartime medical experience has fostered a fundamental desire to improve outcomes by improving practice[4]. In Vietnam, more highly trained medics at the point of wounding and prompt aeromedical evacuation decreased battlefield mortality rate even further [5].

In 1966, the National Academy of Sciences (NAS) published "Accidental Death and Disability: The Neglected Disease of Modern Society" noting trauma to be one of the most significant public health problems

faced by the nation. Concomitant with advances on the battlefield and the conclusions of the NAS was the formal development of civilian trauma centers. In 1976, the American College of Surgeons produced the first iteration of injury care guidelines, the "Optimal Resources for the Care of the Injured Patient." This concept rapidly evolved into the development of formal integrated trauma systems. Trauma centers and trauma systems in the United States have had a remarkable impact on improving outcomes of injured patients [2, 5-18], reducing mortality by up to 15% in mature systems.

However, despite the evolving successes of civilian trauma systems, Operation Desert Shield and Desert Storm in 1992 highlighted a number of issues in which the U.S. military had fallen behind the successful construct fostered by civilian systems of injury care. Inadequacies were formally noted in both preparation and delivery of trauma care in the combat environment [3, 19-21]. Shortly following the terrorist attacks of September 11, 2001, the United States once again had vast numbers of soldiers committed to armed conflict. At this juncture, the medical leadership of the joint forces enacted a plan to emplace a formal system of trauma care in theater to improve the care of the battlefield wounded. The goal was to develop and implement a true trauma system modeled after the successes of civilian systems, but modified to account for the realities of combat. The stated vision of the joint theater trauma system was to ensure that every soldier, marine, sailor, or airman injured on the battlefield has the optimal chance for survival and maximal potential for functional recovery, in other words, to get the right patient to the right place at the right time in order to receive the right care.

The joint military forces of the United States initiated the development of a theater trauma system in May 2004. Initial groundwork included military surgical consultant visits to theater followed by the identification of a trauma surgeon (Trauma System Director) to be placed at the theater medical command headquarters in order to introduce the concept and importance of establishing a trauma system in the theater of operations. After this preparatory phase, a collaborative effort of the Surgeons General of the U.S. military, United States Central Command, the USAISR and the American College of Surgeons Committee on Trauma, formal implementation of the system occurred in November 2004. A trauma system director and a team of six trauma nurse coordinators were deployed to theater in order to address trauma system components and to organize the medical assets and identify discrete deficiencies within the existing medical infrastructure. From these lean beginnings, the Joint Trauma System has grown to an organization of nearly 100 personnel, both civilian and military, worldwide. To support the development of the trauma system, the Joint Theater Trauma Registry (JTTR) was developed to capture injury data including demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcomes. Utilizing data from the JTTR, trauma system leaders were able to develop data driven recommendations for Medical Commands on the battlefield as well as for CENTCOM and CONUS military medical leaders. The evolution of the Joint Theater Trauma System has lead to advances in numerous components of battlefield injury care.

PREVENTION

Since the implementation of the military trauma system, the effect of new prevention measures has been most marked in the reduced number of soldiers killed from combat wounds, with current case fatality rates of 10 %, compared to 16.5% for Vietnam [23] and approximately 25% for the World Wars. Data gathered about injury patterns has driven force protection changes in combatant training and equipment. As the conflict transitioned from a maneuver war in which most injuries were the result of gunshot wounds to an insurgency characterized by ambushes and improvised explosive devices (IEDs), wounding patterns changed from mainly small arms injuries to multiple fragment injuries. Rapid fielding initiatives led to improvements in personal protective equipment and to uparmoring of military vehicles with anecdotal concomitant reports of a decrease in the number and severity of these types of injuries [24].

TRAINING

Numerous trauma training programs, including the Army, Air Force, and Navy Trauma Training Centers associated with nationally renowned Level I trauma centers, have evolved to train providers to treat combat injury and prepare them for the realities of medical care on the battlefield. Others courses, such as Tactical Combat Casualty Care, Emergency War Surgery, and the Joint Forces Combat Trauma Management Course have revolutionized the way medical providers are trained for wartime deployment.

BATTLEFIELD CARE

The JTTR captured demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data on 23,754 casualty injury events from October 2001 through December 2008 for this analysis. Most deaths on the battlefield are due to total body disruption, severe brain injury, or hemorrhage. Little can be done on the battlefield for primary injury from total body disruption or severe brain injury. However, attention to hemorrhage control at the point of wounding is the focus of ongoing efforts. Responding to feedback from medics and corpsman on the battlefield, a number of products and therapeutic devices have been fielded to the battlefield for hemorrhage control including new hemostatic dressings and newly tested and selected tourniquets. Reports from the battlefield thus far have documented efficacy of both dressings and tourniquets in the tactical environment similar to those in the literature [25]. In addition, the new concepts of Tactical Combat Casualty Care (TC3) have revolutionized pre-hospital medical care and resulted in an increase in the number of injured soldiers who survive their injury and make it to a medical treatment facility for attempts at definitive care.

ACUTE CARE FACILITIES

The onset of Operation Iraqi Freedom was marked by a rapid ground influx of combat elements which required intrinsic medical / surgical in order to support the fast paced tempo of the conflict. Surgical support was initially ascribed to small surgical units such as the Army forward surgical team (FST) and the Navy forward resuscitative surgical system (FRSS). Subsequently, more robust hospital elements with more operating room and ICU capability were established throughout Iraq. With the increased capability came an increased capacity to render higher level care to soldiers injured on the battlefield. The larger hospital units were capable of 24/7 operations and could provide trauma care at a standard that would be expected of a major trauma center in the United States.

LEADERSHIP

With the backing of the Central Command Surgeon and the three Surgeons General, the position of trauma system director was rapidly incorporated as a valued consultant position within the theater Medical Command. This leadership position enabled the trauma system director to rapidly implement actionable items such as data collection, standard practice guidelines and performance improvement. With the growth of the trauma system, there is now an established Trauma System Director position in CONUS. At his level, trauma system leaders can give data driven responses over the entire continuum of patient care through level V. These intrinsic leadership entities within the medical system drive advances within the trauma system by direct oversight of the medical processes and advocacy which ultimately leads to better patient care.

PERFORMANCE IMPROVEMENT

To date, over 30 trauma clinical practice guidelines have now been instituted as standards of care within the theater trauma system, including deep venous thrombosis (DVT) prophylaxis, hypothermia prevention, and damage control resuscitation. To illustrate the efficacy of clinical practice guidelines in theater, with compliance rates greater than 80%, the rate of hypothermia upon presentation has been decreased from 7% to < 1%, burn resuscitation morbidity has decreased from 36% to 18%, and massive transfusion mortality has decreased from 32% to 20 %.

PROFESSIONAL RESOURCES

Professional resources are a finite and precious commodity not only for the maintenance of the trauma system, but also for the medical care of injured warriors. Evaluation of the surgical assets in theater by the trauma system made a strong case for redeploying many of the smaller surgical units after the larger combat support hospitals were established in order to conserve vital surgical resources, especially in light of the ongoing nature of the conflict and the likelihood of subsequent deployments for these individuals.

RESEARCH

Prior to the current conflict, much of the data on combat injury was derived from the Vietnam conflict and the Wound Data and Munitions Effectiveness Team (WEDMET) database [26-28]. Before the development of the formal combat trauma system, little data was being published about the conflict and the data being published was largely small series and case reports [29-40]. With the belief that research drives doctrine, a concerted effort was put forth to field the Joint Theater Trauma Registry (JTTR). This registry is a concise form developed to capture demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data along with a brief physical examination. To date, with improved registry capture as a direct result of the trauma system, the JTTR database contains >23,500 soldier injury records. Through an approved IRB process, this database is available for valid research endeavors. The results being derived from this data will likely drive the course of combat trauma care for decades to come.

Ongoing joint military research efforts include the following:

- Hemostasis
  - Battlefield tourniquets
  - Hemostatic dressings
  - Recombinant factor VIIa
- Resuscitation
  - Damage control resuscitation
- Acute care
  - ED Thoracotomy
  - Management of penetrating colon injury
  - Vascular injury management

Joint Theater Trauma Registry was utilized to publish over 152 peer reviewed manuscripts in the surgical literature, publications which educate subsequent providers deploying to care for the war injured.

EDUCATION AND ADVOCACY

Combat injury is the most substantial healthcare issue in theater. Two thirds of all admissions at combat support hospitals are for injury. One goal of this system has been to educate soldiers, leaders, and medical providers and commanders with respect to the importance of maintaining the system which has been built. Coalition partners, including the British, Canadian, German and Australian partners have expressed sincere interest in broadening the system into a multinational coalition venture. The combat trauma system has become the standard of care on the battlefield.

CONCLUSIONS

The combat trauma system has improved combat casualty care to a level never seen before. Combat casualties injured on the battlefield have a greater chance than ever before of surviving their injuries and returning home. Though this marked improvement in outcomes is multifactorial, the continued evolution and development of a deployed trauma system will certainly have a lasting impact on the delivery of healthcare on the battlefield of today and the future.

In summary, full implementation of the joint theater trauma system will insure that the credo, "RIGHT PATIENT, RIGHT PLACE, RIGHT TIME, RIGHT CARE' will be met and lives will continue to be saved as a consequence.

REFERENCES

1. Tracy, E., *Combining military and civilian trauma systems: the best of both worlds.* Topics in Emergency Medicine, 2005. **27**: p. 170-175.

2. Trunkey, D.D., *History and development of trauma care in the United States.* Clin Orthop Relat Res, 2000(374): p. 36-46.

3. Trunkey, D.D., *In search of solutions.* J Trauma, 2002. **53**(6): p. 1189-91.

4. DeBakey, M.E., *History, the torch that illuminates: lessons from military medicine.* Mil Med, 1996. **161**(12): p. 711-6.

5. Hoff, W.S. and C.W. Schwab, *Trauma system development in North America.* Clin Orthop Relat Res, 2004(422): p. 17-22.

6. Demetriades, D., et al., *Trauma deaths in a mature urban trauma system: is "trimodal" distribution a valid concept?* J Am Coll Surg, 2005. **201**(3): p. 343-8.

7. Jurkovich, G.J. and C. Mock, *Systematic review of trauma system effectiveness based on registry comparisons.* J Trauma, 1999. **47**(3 Suppl): p. S46-55.

8. Mann, N.C., *Assessing the effectiveness and optimal structure of trauma systems: a consensus among experts.* J Trauma, 1999. **47**(3 Suppl): p. S69-74.

9. Mann, N.C. and R.J. Mullins, *Research recommendations and proposed action items to facilitate trauma system implementation and evaluation.* J Trauma, 1999. **47**(3 Suppl): p. S75-8.

10. Mann, N.C., et al., *Systematic review of published evidence regarding trauma system effectiveness.* J Trauma, 1999. **47**(3 Suppl): p. S25-33.

11. Mullins, R.J., *A historical perspective of trauma system development in the United States.* J Trauma, 1999. **47**(3 Suppl): p. S8-14.

12. Mullins, R.J. and N.C. Mann, *Population-based research assessing the effectiveness of trauma systems.* J Trauma, 1999. **47**(3 Suppl): p. S59-66.

13. Mullins, R.J. and N.C. Mann, *Introduction to the Academic Symposium to Evaluate Evidence Regarding the Efficacy of Trauma Systems.* J Trauma, 1999. **47**(3 Suppl): p. S3-7.

14. Mullins, R.J., et al., *Influence of a statewide trauma system on location of hospitalization and outcome of injured patients.* J Trauma, 1996. **40**(4): p. 536-45; discussion 545-6.

15. Nathens, A.B., et al., *Effectiveness of state trauma systems in reducing injury-related mortality: a national evaluation.* J Trauma, 2000. **48**(1): p. 25-30; discussion 30-1.

16. O'Keefe, G.E., et al., *Ten-year trend in survival and resource utilization at a level I trauma center.* Ann Surg, 1999. **229**(3): p. 409-15.

17. Trunkey, D.D., *Trauma care systems.* Emerg Med Clin North Am, 1984. **2**(4): p. 913-22.

18. West, J.G., et al., *Trauma systems. Current status--future challenges.* Jama, 1988. **259**(24): p. 3597-600.

19. *Operation Desert Storm: Full Army Medical Capability Not Achieved*. 1992. Washington, DC: GAO/NSIAD-92-175.

20. *War Time Medical Care: DOD Is Addressing Capability Shortfalls, but Challenges Remain*. 1996. Washington, DC: GAO/NSIAD-96-224.

21. *War Time Medical Care: Personnel Requirements Still Not Resolved*. 1996. Washington, DC: GAO/NSIAD-96-173.

23. Holcomb, J.B., et al., *Understanding combat casualty care statistics.* J Trauma, 2006. **60**(2): p. 397-401.

24. Gondusky, J.S. and M.P. Reiter, *Protecting military convoys in Iraq: an examination of battle injuries sustained by a mechanized battalion during Operation Iraqi Freedom II.* Mil Med, 2005. **170**(6): p. 546-9.

25. Lakstein, D., et al., *Tourniquets for hemorrhage control on the battlefield: a 4-year accumulated experience.* J Trauma, 2003. **54**(5 Suppl): p. S221-5.

26. Bellamy, R.F., *The causes of death in conventional land warfare: implications for combat casualty care research.* Mil Med, 1984. **149**(2): p. 55-62.

27. Bellamy, R.F., *Contrasts in combat casualty care.* Mil Med, 1985. **150**(8): p. 405-10.

28. Bellamy, R.F., P.A. Maningas, and J.S. Vayer, *Epidemiology of trauma: military experience.* Ann Emerg Med, 1986. **15**(12): p. 1384-8.

29. Bilski, T.R., et al., *Battlefield casualties treated at Camp Rhino, Afghanistan: lessons learned.* J Trauma, 2003. **54**(5): p. 814-21.

30. Butler, F.K., Jr., J. Hagmann, and E.G. Butler, *Tactical combat casualty care in special operations.* Mil Med, 1996. **161 Suppl**: p. 3-16.

31. Chambers, L.W., et al., *Initial experience of US Marine Corps forward resuscitative surgical system during Operation Iraqi Freedom.* Arch Surg, 2005. **140**(1): p. 26-32.

32. Cho, J.M., et al., *Operation Iraqi Freedom: surgical experience of the 212th Mobile Army Surgical Hospital.* Mil Med, 2005. **170**(4): p. 268-72.

33. Gawande, A., *Casualties of war--military care for the wounded from Iraq and Afghanistan.* N Engl J Med, 2004. **351**(24): p. 2471-5.

34. Koehler, R.H., R.S. Smith, and T. Bacaner, *Triage of American combat casualties: the need for change.* Mil Med, 1994. **159**(8): p. 541-7.

35. Mabry, R.L., et al., *United States Army Rangers in Somalia: an analysis of combat casualties on an urban battlefield.* J Trauma, 2000. **49**(3): p. 515-28; discussion 528-9.

36. Patel, T.H., et al., *A U.S. Army Forward Surgical Team's experience in Operation Iraqi Freedom.* J Trauma, 2004. **57**(2): p. 201-7.

37. Peake, J.B., *Beyond the purple heart--continuity of care for the wounded in Iraq.* N Engl J Med, 2005. **352**(3): p. 219-22.

38. Peoples, G.E., J.R. Jezior, and C.D. Shriver, *Caring for the wounded in Iraq--a photo essay.* N Engl J Med, 2004. **351**(24): p. 2476-80.

39. Place, R.J., R.M. Rush, Jr., and E.D. Arrington, *Forward surgical team (FST) workload in a special operations environment: the 250th FST in Operation ENDURING FREEDOM.* Curr Surg, 2003. **60**(4): p. 418-22.

40. Stevens, R.A., et al., *The U.S. Navy's forward resuscitative surgery system during Operation Iraqi Freedom.* Mil Med, 2005. **170**(4): p. 297-301.